CHAPTER 4
Methods for Developing Minimum Level Criteria

CONCEPTUAL BASIS FOR MINIMUM LEVELS: MANAGEMENT CONCERNS AND OBJECTIVES

Management of a natural resource is a complex process requiring consideration of a number of variables. Establishment of a minimum level is an important component of this process; a minimum level, however, is only one aspect of a whole range of variation that must be considered as part of management efforts. Other aspects include average levels, maximum levels, and seasonal variability and frequency of flooding and drought events. To focus on only one aspect of the lake's hydrology would be an overly simplistic treatment of the whole range of complex ecosystem interactions that need to be considered in order to protect this water body.

Because of the intrinsic ecologic complexity of many natural water bodies, disagreement is common regarding the nature of the role of the MFL within the larger picture of resource management. The MFL marks a point at which a water supply withdrawal will cause *significant harm* to a surface water body, aquifer, or area ecology (see MFL rule definitions in **Chapter 1**). The MFL rule provides for setting an MFL on the basis of "best available information," and typically an MFL is set for a water body despite the clear recognition that more studies are required in order to understand fully some of the more complex relevant hydrologic/ecologic interactions. Rather than waiting until all information is available before making a management decision, MFL development is based on "best available information." This process also includes an adaptive approach that 1) sets water inflows and levels based on best available information, expert opinion and assumptions and analyses derived from conceptual and mathematical modeling, 2) monitors the results for success or failure, 3) identifies research needs and reevaluates water level and flow targets and 4) provides for adjustment of water level and inflow as needed, on the basis of results from monitoring and research.

Historical data and accounts provide a means for identifying ecologic changes to the system during the previous century. **Chapter 2** describes the pre-development watershed conditions. The most notable changes to Lake Istokpoga over the past half-century include the following:

- Stabilization of water levels, thereby eliminating periodic occurrences of extreme high and low water levels characteristic of historic Lake Istokpoga hydrology.

- Alteration of the natural seasonal pattern of rainy-season high water levels and dry-season low water levels (current lake management tends to maintain higher lake levels during the dry season, for water supply, and lower levels during the rainy season, for flood control).
- Alteration of natural flowways out of Lake Istokpoga (this function has been largely assumed by canals and is regulated by water control structures).
- Draining of lands within the historic floodplain for development of agriculture and homesites.
- Large increases in loading of pollutants, mostly nitrogen and phosphorus, from upstream sources.
- Proliferation of nonnative and nuisance plant species that disrupt natural systems in the lake and littoral wetlands and negatively affect navigation and recreation.
- Accumulation of organic sediments that impact fish and wildlife resources.

Several projects currently address these resource management issues in the Lake Istokpoga watershed. The establishment of a minimum level for Lake Istokpoga will define low water levels that cause *significant harm*. Efforts such as the Kissimmee Basin Water Supply Plan, the Comprehensive Everglades Restoration Plan (CERP) and the FWC's wildlife habitat management programs provide the means to manage high-water events, to address water storage needs and to restore some of the lake's lost hydrologic and ecologic functions.

Considering impacts to Lake Istokpoga from alterations in hydrology, water chemistry and ecology, District specialists suggest that management objectives for Lake Istokpoga should address the following concerns:

- Provision of periodic drawdowns designed to approximate historic low water level conditions more closely, thereby providing an opportunity for sediment consolidation and control of nuisance vegetation.
- Reevaluation of the current regulation schedule to incorporate a more natural pattern and timing of water levels to reflect seasonal and other historical fluctuations.
- Protection and enhancement of remaining littoral zone and fringing swamp wetlands through improved management practices, including maintenance of more appropriate water levels.
- Improvement of water quality in the lake and tributaries by identifying and managing sources of inflows of pollution and storm water runoff.

Development of minimum level criteria provides an additional tool needed for addressing these goals and objectives. The minimum level criteria will specifically identify the range of water levels in the lake that will cause *significant harm* to the resource.

METHODS STUDIED IN DEVELOPING MFL CRITERIA FOR LAKE ISTOKPOGA

Methods Used in Other Florida Lakes

Lake Okeechobee (SFWMD)

Lake Okeechobee is a large, shallow, eutrophic lake located in south central Florida that serves as a multipurpose reservoir to meet regional water management needs. In 2000, the SFWMD established a MFL for Lake Okeechobee based on achieving balanced protection of the following four water resource functions: 1) preventing saltwater intrusion into the Biscayne Aquifer, 2) meeting water storage and supply needs, 3) providing habitat for fish and wildlife and 4) supporting navigation and recreational use. Lake Okeechobee water depth is controlled by a regulation schedule, and allocations of lake water during drought periods are based on a drought management plan.

Defining the criteria for Lake Okeechobee minimum water levels involved the examination of drought management plans, historical data and ecologic research results. Drought management plans indicated that total annual rainfall in south Florida is highly variable. Historical data showed that when lake water levels fell below 10.5 feet, limitations of outlet structures made it difficult to provide water to protect coastal wellfields against saltwater intrusion. Ecologic research showed that, in regard to water level, a 1-foot decline in lake levels from 12 feet to 11 feet brought a 20 percent loss of aquatic habitat and other significant impacts, which became worse as water levels declined below 11 feet. In regard to determining a minimum duration and return frequency for declaration of a violation of the minimum water level, little pertinent ecologic information existed, so the minimum duration and return frequency components were estimated on the basis of analysis of historical records from 1952 to 1995.

The *significant harm* criteria for Lake Okeechobee were based on the relationship between water levels in the lake and the ability to 1) protect the coastal aquifer, 2) supply water to Everglades National Park, the Everglades Agricultural Area, Seminole Indian Tribe Reservation lands and the Caloosahatchee and St. Lucie basins, 3) provide littoral zone habitat for fish and wildlife and 4) ensure navigational and recreational access. *Significant harm* to navigation and recreation was determined on the basis of 1) water depths needed for safe navigation of the Okeechobee Waterway, 2) bathymetry maps and 3) discussions with marina operators and boat captains. Minimum level criteria for Lake Okeechobee are as follows:

> A MFL violation occurs in Lake Okeechobee when an exceedance, as defined herein, occurs more than once every six years. An exceedance is a decline below 11 feet NGVD for more than 80 nonconsecutive or consecutive days during an eighteen-month period. The eighteen-month period shall be initiated following the first day Lake Okeechobee falls below 11 feet NGVD and shall not include more than one wet season, defined as May 31st through October 31st, of any given calendar year (Chapter 40E-8.221 [1], F.A.C.)

Southwest Florida Water Management District Lakes

In 1996, the Southwest Florida Water Management District convened a Technical Advisory Committee to develop minimum flows and levels methodologies. The Committee was composed of SWFWMD staff, representatives of local governments and interested citizens. Separate subcommittees were formed to develop specific methodologies for aquifers, lakes and wetlands. As a result of work performed by the Lake Level Subcommittee, the SWFWMD Governing Board adopted in 1998 a methodology for establishing minimum lake levels. Three categories of lakes were identified in this methodology: Category 1 lakes (with fringing bald cypress wetlands and water levels that currently rise to an elevation expected to maintain fully the integrity of the wetlands), Category 2 lakes (with fringing bald cypress wetlands that have been structurally altered such that lake water levels do not rise to levels formerly attained) and Category 3 lakes (with no fringing bald cypress) (see SWFWMD 1999, 2001 and 2002).

Establishment of minimum levels for lakes fringed with bald cypress wetlands (as is Lake Istokpoga) is preceded by the compilation of lake stage data, the calculation of stage-duration percentile statistics, the characterization of the data as "historic" or "current," the determination of normal pool and control point elevation, and the development of a region-specific reference lake water regime. Minimum levels are established based on a series of dichotomous choices concerning the type of stage data available and the relative elevations of the suite of descriptive stage-duration statistics. The definition of a "minimum level" for those SWFWMD lakes is as follows:

- The "minimum level" is the long-term level of a surface water, water table or potentiometric surface at which further withdrawals would be significantly harmful to the water resources of the area and which may provide for the protection of nonconsumptive uses (e.g., recreational, aesthetic and navigation). Such level shall be expressed as an elevation in feet relative to the National Geodetic Vertical Datum (1929) or in feet relative to the North American Vertical Datum (1988) and includes Minimum Wetland Levels, High Minimum Lake Levels, Minimum Lake Levels and Saltwater Intrusion Minimum Aquifer Levels.

A "high minimum lake level" (HMLL) and "minimum lake level" (MLL) are further defined as follows:

- The "high minimum lake level" is the minimum level that corresponds to the elevation that the lake water level must equal or exceed 10 percent of the time on a long-term basis. For evaluation of hydrologic data for the purpose of establishing minimum levels, "long-term" means a period that spans the range of hydrologic conditions that can be expected to occur, based on historical records. Typically, a period of six or more years is

considered sufficient for establishment of long-term conditions; however, shorter periods may be considered to be representative of long-term conditions, based on reasonable scientific judgment.

- The "minimum lake level" is the minimum level that corresponds to the elevation that the lake water level must equal or exceed 50 percent of the time on a long-term basis.

The term *significant harm* was deemed by the SWFWMD Governing Board to be equivalent to "significantly altered." As such, the standards and methods associated with the definition of "significantly altered" wetlands, as originally developed by the Wetland Subcommittee to identify isolated wetlands that have been "significantly altered" as a result of reduced hydroperiods (SWFWMD 1999), would be applied to lakes with fringing bald cypress wetlands.

The SWFWMD approach to MFLs differs from that of the SFWMD, especially in the basic definition of *significant harm* (see SFWMD definition outlined in **Chapter 1**, specifically **Figure 1**). Furthermore, the types of lakes found within the SWFWMD are different from those typically found within the SFMWD. For these reasons, direct application of the SWFWMD methodology is not appropriate here. Use of the rationale for protection of fringing wetlands, however, is an important and applicable consideration included in the MFL concept developed for Lake Istokpoga.

St. Johns River Water Management District Lakes

The St. Johns River Water Management District (SJRWMD) defines MFLs as the minimum water levels and/or flows necessary to prevent *significant harm* to the water resources or ecology of an area resulting from water withdrawals permitted by the SJRWMD. These MFLs define how often and for how long the high, average and low water levels and/or flows should occur in order to prevent *significant harm*. The SJRWMD defines *significant harm* as "unacceptable long-term changes to ecosystem structure or the long-term or short-term unacceptable decline of important ecosystem functions caused by anthropogenic alteration of system hydrology" (SJRWMD 2001). The hydrologic (water level and/or flow) conditions defined by the MFLs are similar to, but are usually lower than, existing hydrologic conditions (see **Figure 26**) (SJRWMD 2001). Three to five MFL criteria are usually defined for each aquatic system: minimum infrequent low, minimum frequent low, minimum average, minimum frequent high and minimum infrequent high (**Figure 27**). These MFL categories directly correspond to community types typically found along the hydrologic gradient upslope from the water body, each with different minimum hydroperiod requirements. These communities include aquatic (open water), slough, marsh, swamp, wet prairie and hydric hammock.

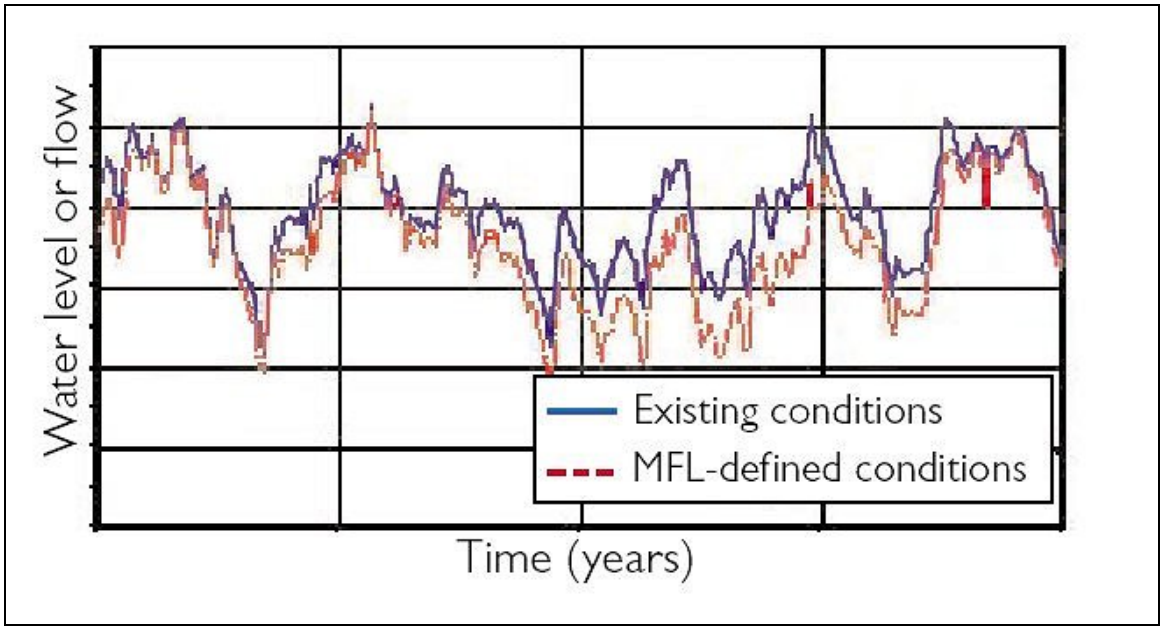

Figure 26. Comparison of Typical Hydrograph and MFL-Defined Minimum Level Hydrograph as Established by the St. Johns River Water Management District (Source: SJRWMD 2001).

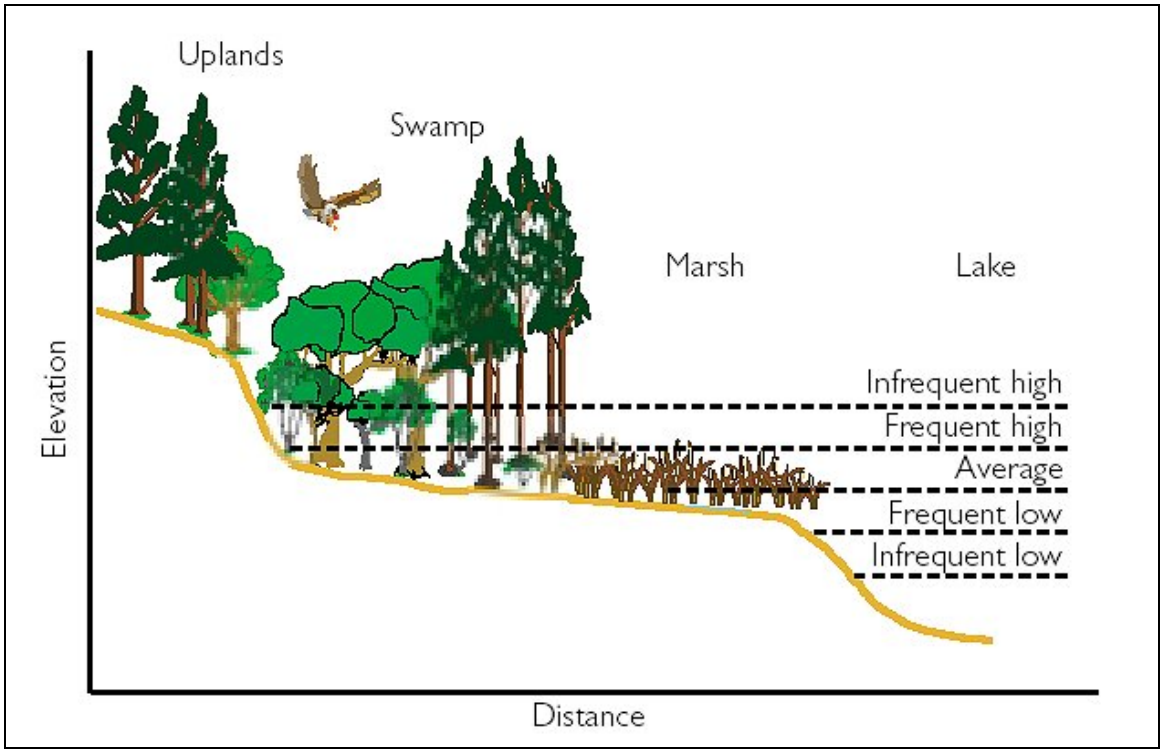

Figure 27. Five Different Potential MFLs as Defined by the St. Johns River Water Management District (Source: SJRWMD 2001).

The SJRWMD defines these categories as follows:

- The "minimum infrequent low" means an acutely low surface water level or flow with an associated frequency and duration that may occur during periods of extreme drought. Below this level there will be a significant negative impact on the biota of the surface water, which includes associated wetlands.
- The "minimum frequent low" means a chronically low surface water level or flow that generally occurs only during periods of reduced rainfall. This level helps prevent deleterious effects to the composition and structure of floodplain soils, to the species composition and structure of floodplain and instream biotic communities, and to the linkage of aquatic and floodplain food webs.
- The "minimum average" means the surface water level or flow necessary over a long period to maintain the integrity of hydric soils and wetland plant communities.
- The "minimum frequent high" means a chronically high surface water level or flow with an associated frequency and duration. This level allows for inundation of the floodplain at a depth and duration sufficient to maintain wetland functions.
- The "minimum infrequent high" means an acutely high surface water level or flow with an associated frequency and duration. This level is expected to be reached or exceeded during or immediately after periods of high rainfall so as to allow for inundation of a floodplain at a depth and duration sufficient to maintain biota and the exchange of nutrients and detrital material.

The SJRWMD approach to MFLs differs significantly from that of the SFWMD, both in the basic definition of *significant harm* (**Chapter 1** and **Figure 1**) and in the derivation of the MFL from existing conditions. Direct application of the SJRWMD methodology to Lake Istokpoga is not feasible, but consideration of lake wetlands will be included in the development of the minimum level for Lake Istokpoga.

Additional Methods

Additional approaches that were considered during the development of MFL criteria for Lake Istokpoga are the following:

- Analysis of historic and current hydrologic conditions. A fairly robust set of 1936–2003 water level data for Lake Istokpoga is available from the SFWMD's DBHYDRO database. This record includes several decades of figures from the periods before and after alteration of the lake's natural hydropattern. A comparison of pre-alteration and current conditions is useful for understanding the hydrologic changes that have occurred.

- Study of low water levels' impact on water supply, navigation, recreation and water quality. The needs of the Istokpoga basin are examined in order to determine if there is a point at which these resource functions are significantly harmed.
- Study of natural systems' hydrologic requirements. Analysis of the hydrologic requirements of littoral zone and fringing swamp vegetation communities can be conducted from existing bathymetry and land use datasets. Most wildlife and fish are ultimately dependent on these vegetation communities as their vital habitat, and therefore the health of the aquatic and surrounding wetland vegetation communities is considered essential.

Because each of these three approaches is able to focus on a unique resource function and because sufficient data exist to conduct each analysis, all three have been used to provide a result that most effectively considers the overall Lake Istokpoga system. The following section discusses in more detail each of these three approaches.

METHODS USED IN DEVELOPING MFL CRITERIA FOR LAKE ISTOKPOGA

Analysis of Historic and Current Hydrologic Conditions

A long-term time series of measured water level data on Lake Istokpoga is available from the SFWMD's DBHYDRO Database (this database is available at: http://www.sfwmd.gov/org/ema/dbhydro/). Specific information about the files containing relevant water level data is presented in **Table 16**.

The graph of this time series of water levels (**Figure 16**) shows three distinct, partially overlapping periods starting in 1936 and corresponding to three different water management practices, as follows: 1936 to 1963; 1963 to the present; and 1989 to the present. In 1963 lake levels began to be managed for flood control; in 1989 lake levels began to be managed for navigation, recreation and water supply purposes. An analysis of water levels during these three periods was conducted in order to characterize the different water level regimes: 1) no controls, 2) flattened highs, and 3) flattened highs and lows. Then descriptive statistics for these three periods were compared so as to determine changes resulting from lake management.

- During the 1936–1963 period, lake levels were unconstrained; this period theoretically reflects a "historic" condition.
- From 1963 to the present—the period following construction of the S-68 Structure—high water events were essentially eliminated as lake levels become managed for flood control.
- From 1989 to the present—the period following the commencement of lake management for navigation, recreation

and water supply—low water levels (water levels less than 36.5 feet NGVD) did not occur (excluding the period of a controlled drawdown for environmental enhancement).

Table 16. Water Level Data in the SFWMD's DBHYDRO Database.

DBHYDRO Element	Element Description	Value	Value Description
DBKEY	Station number in DBHYDRO Database	00231	Station number
STATION	Station name in DBHYDRO Database	S68_H	Sample collected at the headwater (lake) side of the S-68 Structure
AGENCY	Source of the data	USGS	United States Geological Survey
COUNTY	County where monitoring station resides	HIG	Highlands
TYPE	Data type	STG	Surface water stage
UNITS	Data units	FT NGVD29	Feet, NGVD29 Datum
STAT	Statistic	MEAN	Mean for time unit
FQ	Frequency (time-unit) of reported datum	DA	Time unit of one day
START	First day of record	1936	Year of 1936
END	Last day of record	2002	Note: this is periodically updated as more data are processed and made available
LAT	Latitude of monitoring station	271948	27.1948 North
LONG	Longitude of monitoring station	811515	81.1515 West
SECTION	Section where monitoring station resides	20	Section block 20 within the Township/Range
TOWN	Township where monitoring station resides	36	Township 36 South
RANGE	Range where monitoring station resides	31	Range 31 East
ALTERNATE ID	Alternate station number in DBHYDRO Database	2271700	Alternate station number

Evaluation of Low Water Levels' Impact on Supply, Navigation/Recreation and Water Quality

Water Supply Issues and Constraints

Unlike urban areas within the Istokpoga basin, agricultural areas south of Lake Istokpoga depend on the lake for water (for irrigation) during dry periods. The

agricultural operations within the Lake Istokpoga–Indian Prairie basin have experienced a series of water shortages related to a lack of supply from Lake Istokpoga and of runoff from the basin. During the late 1980s and early 1990s, several actions were taken by the SFWMD to correct these problems. An analysis of the Lake Istokpoga–Indian Prairie system, completed as part of the Kissimmee Basin Water Supply Plan (SFWMD 2000a), suggests that although there appears to be sufficient water to meet the current water supply demands, surface water from the Lake Istokpoga–Indian Prairie basin is not sufficient to meet all of the projected future (2020) water needs. The recommendations considered as part of the KB Plan were aimed at the development of alternative supplies to meet the projected future needs.

To address the projected future surface water deficits more fully, the KB Plan advisory committee formed a subcommittee to identify issues within the Istokpoga basin and to review an analysis developed in responses to these concerns. The group also identified and discussed several water resource options specific to the Istokpoga basin for addressing the projected shortfalls in water supply. Two types of options were identified as ways to make additional water available or to reduce projected demand. Water source options that were identified as having the greatest potential for meeting future demands included backpumping from Lake Okeechobee, importing water from the Kissimmee River at S-84, changing the minimum operational flows from Lake Istokpoga and constructing regional reservoirs.

The ability to increase storage in Lake Istokpoga by maintaining water levels above current levels was also considered. This option received the largest amount of debate from the KB Plan focus group. Concerns were raised about the proper regulation schedule and the minimum operational levels for the lake. Some committee members thought the existing level of 37.5 feet was too low from the viewpoint of resultant navigational constraints. Others thought that the lake did not fluctuate enough and should be allowed to drop to 36.5 feet on occasion. Concerns were also expressed about the time of the year at which these levels should be achieved. The majority of participants agreed that maximizing the range of annual water level fluctuations while maintaining navigation and flood protection constraints would be beneficial.

Water supply within the Lake Istokpoga basin is not a concern at this time; nevertheless, water supply projects are under way to investigate the potential future needs and supply shortfalls (SFWMD 2000a). These issues will be further discussed and addressed by future KB Plan updates and the Lake Okeechobee Watershed (LOW) CERP Project. Lake Istokpoga's water supply function is therefore not considered a constraint in developing MFL criteria at this time. But a comparison of the proposed minimum level with the current Regulation Schedule for Lake Istokpoga will be conducted to determine if the proposed minimum level could potentially affect water supply. Future updates to the MFL criteria will consider water supply issues and any related need for adjustments to MFL criteria.

Recreational Use and Navigation

Lake Istokpoga's large size permits a wide range of recreational activities such as fishing, hunting, waterskiing, wildlife observation and boating. Arbuckle Creek is a favorite canoeing and kayaking route and includes the lake's northern shore. Many of these recreational/navigational uses depend on the existence of adequate lake levels, flow and water quality to support healthy plant and animal communities within the lake. Therefore, maintenance of minimum levels is important for access to and enjoyment of the resource.

In 1974, the SFWMD's Governing Board adopted a rule (Part I, Chapter 40E-22, F.A.C) that contains a Regional Water Shortage Plan for the Lake Istokpoga–Indian Prairie Area. The plan established a minimum permissible schedule for Lake Istokpoga and the project canals into which the lake discharges. This Governing Board action was based on a 1974 report entitled *Report on Surface Water Availability in Lake Istokpoga–Indian Prairie Area* (SFWMD 1991). This report does not provide a detailed ecologic-impact analysis associated with the minimum level recommendations, and it appears that the lake's ecology was not a determining factor. The report's justification for the recommended Lake Istokpoga minimum level focused on recreational boating and aesthetic values. The report states that "…based on staff knowledge of recreational navigation access problems in the lake and lake residents' views of desirable lake stages as expressed at public meetings and in correspondence to the SFWMD, a judgment determination was made setting minimum lake stage at 37.0 feet mean sea level…" (SFWMD 1991).

Stakeholder comments and input at public meetings indicate that problems with localized access to the lake may appear when water levels drop below 38 feet NGVD. In addition, the impacts of low water levels on navigation and recreational access are transient and are eliminated when water levels rise. The effects of prolonged low water events on navigation and recreational access are included as a consideration in MFL development.

Relationship between Water Quality and Lake Levels

The relationship between water quality and water levels in Lake Istokpoga is largely undefined. It is assumed, however, that internal cycling mechanisms and nutrient loading from tributaries are the dominant factors controlling water quality.

The primary origin of nutrient inputs to the lake is storm water runoff from upstream sources. The magnitude of these inputs is independent of water levels in Lake Istokpoga, since the inputs are controlled by rainfall patterns within the basin. Generally, water quality is poorer in the northern end of the lake, where Arbuckle and Josephine creeks empty into Lake Istokpoga. Water quality measurements in the southern end of the lake (near the S-68 Structure outflow) indicate that high amounts of nutrients are removed from the water column through uptake by aquatic and littoral zone vegetation.

One activity that may temporarily affect water quality is the chemical treatment of aquatic vegetation (such as hydrilla) (O'Dell *et al.* 1995). This effect, however, is not the direct result of lower water levels, although vegetation control is usually exercised during low water periods. Death and decay of the chemically treated vegetation can lead to release of nutrients stored in the plant tissue, raising water column nutrient levels. The severity of such treatments' impact on water quality depends on the extent of the treatment area and on the type of herbicide applied. Fluridone, which is used for large-scale and whole-lake treatment of hydrilla, is slow-acting and typically has a response time of several weeks or longer. Studies of water quality after treatment generally indicate a temporary increase in phosphorus and chlorophyll concentrations and a decrease in Secchi depths (O'Dell *et al.* 1995). This increase in nutrients has not been associated with algal blooms or other environmental degradation, and some released phosphorus may have been lost from the lake through outflows.

Because of the assumed indirect or weak relationship between water quality and water levels, as well as the lack of data relating water levels to water quality, this factor was not included in the development of MFL criteria for Lake Istokpoga.

Analysis of Natural Systems' Hydrologic Requirements

Aquatic and Wetland Vegetation Communities

Lake Istokpoga's littoral zone and aquatic vegetation communities provide critical habitat for fish and wildlife. Protection of aquatic and littoral zone vegetation is essential because this habitat affords needed spawning and nesting areas and protective cover and serves as a nursery for organisms that are food for fish and wildlife.

Because littoral zone wetland hydropatterns are related to lake levels, consideration of the hydroperiod requirements of these littoral zone wetland communities was a key factor in MFL criteria development for Lake Istokpoga. Fish and wildlife communities rely on in-lake and adjacent wetlands as critical habitats, and thus the analysis of aquatic and wetland vegetation communities' hydrologic requirements can provide a basis for examining lake levels' potential impact on the local ecology. It is assumed that if the average hydroperiod for a wetland type is shortened for several years in succession, then the community will begin to shift to another community type more characteristic of drier habitats. With this change comes an altered function within the landscape and altered value to fish and wildlife.

The point at which these wetlands experience *significant harm* associated with lake level changes was determined by using the typical water level and hydroperiod ranges reported for the various wetland types. By comparing lake levels and wetland elevations, water depths within littoral wetlands were determined. The extent of lake wetlands was obtained from land use maps (FDOT 1995), and the natural range of wetland hydrologic conditions was obtained from a review of the scientific literature. Ground elevations within these wetlands were determined from a recent bathymetry

study conducted for the FDEP (ReMetrix 2003) and were used to specify the average lake levels required to sustain each community type.

Fish Communities

Lake Istokpoga's fish communities are important components of the local ecologic community and economy. Small fish are important food sources for wading birds and raptors, supporting one of the largest known concentrations of osprey (Stewart 2001). Fishing and associated activities support a significant recreation-based economy, ranging from sales of fishing-related equipment (from bait to boats) to fishing guide services and year-round fishing camps. The local ecologic community and the local economy both rely on the maintenance of a healthy and productive fish community.

Fisheries management includes implementation of slot limits for catches, vegetation management and, more recently, drawdown of lake levels to remove accumulated sediments and facilitate treatment of weedy aquatic vegetation. The effects of low water levels on the fishery resource were considered as part of the MFL criteria. Fish survey data were impacts that could be directly related to the 2001 drawdown event and that persisted for more than two years.

Bird Communities

Many bird species depend on a specific type of habitat for feeding and/or successful reproduction. A disturbance, whether natural or human induced, can have a significant impact on population distribution and reproductive success. Some bird species use several habitat types for different purposes. For instance, wading birds typically forage for food in marshes or in shallow open-water areas but roost and nest in trees (usually swamps). Some bird species are directly dependent on water levels for successful feeding (Kushlan 1976, 1986, 1989; Ogden *et al.* 1976). Low water levels can favor fish catches by wading birds and raptors by concentrating prey into smaller spatial areas and shallow water. But excessive and prolonged low water levels may negatively impact littoral zone wetlands, which are vital habitats for some bird species. The health and diversity of aquatic and wetland habitats are essential elements in supporting a vigorous and diverse bird population.

The habitat requirements of a wide range of bird species found within the Lake Istokpoga area were researched in order to help determine the relationships between water levels and the well-being of the various bird communities. An examination was undertaken of the potential impact of low water levels on bird breeding cycles and on plant communities used by birds. The sources of bird habitat information included books, Internet resources and conversations with local bird experts. Low water conditions that would cause reproductive failure of successive year-classes may negatively impact local bird populations. Several successive years of impacts may lead to *significant harm*.